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(71) Applicant: International Business Machines  
Corporation  
Armonk, N.Y. 10504 (US)

(72) Inventors:  
• Kolke, Tetsushi  
Sagamihara-shi, Kanagawa-ken (JP)

• Kodate, Manabu  
Yokohama-shi, Kanagawa-ken (JP)  
• Ikezaki, Mitsuru  
Sagamihara-shi, Kanagawa-ken (JP)

(74) Representative: Ling, Christopher John  
IBM United Kingdom Limited,  
Intellectual Property Department,  
Hursley Park  
Winchester, Hampshire SO21 2JN (GB)

(54) Liquid crystal display

(57) The present invention is related to a liquid crystal display in which the antistatic measures in the manufacturing process is taken, and a method for manufacturing the same, and intended for providing a liquid crystal display in which the occurrence of static failure before the formation of the short ring is prevented, and a method for manufacturing the same. On a glass substrate (2), gate lines (46) are formed. The gate lines (46) are disconnected, and in the disconnected portion, discharge projections (52) and (54) are formed on both

sides of a discharge gap (50). The discharge projections (52) and (54) are positioned substantially at the centre of the edges of the disconnected portion of the gate lines (46). On the gate lines (46) and in the discharge gap 50, a gate insulation film 56 is formed. Two through holes 58 are made in the gate insulation film (56) in the vicinity of the discharge projections (52) and (54) of each gate line (46). A metal wiring layer (48) is formed on the gate insulation film (56) so as to fill in the through holes (58).

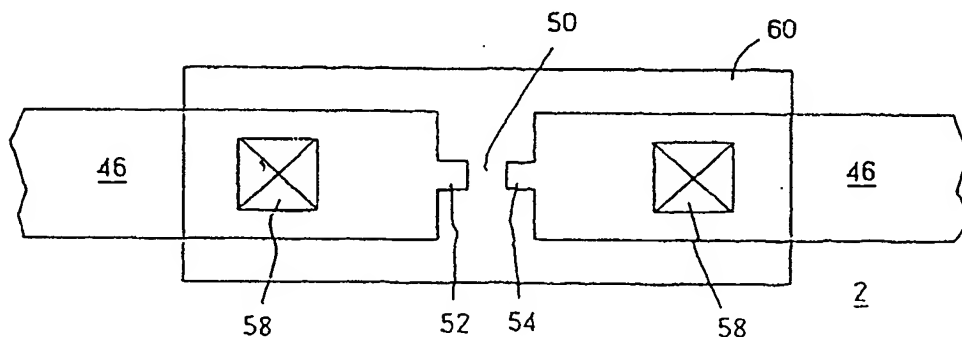
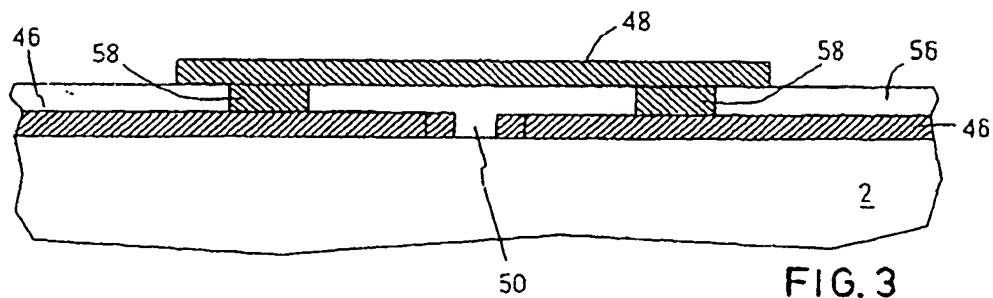


FIG. 2

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**Description****Field of the Invention**

The present invention is related to a liquid crystal display and a method for manufacturing the same, and particularly to a liquid crystal display in which counter-measures against static electricity are taken in the manufacturing process thereof, and a method for manufacturing the same.

**Background art**

In the active matrix liquid crystal display using TFTs (Thin Film Transistors) or the like as switching elements, a liquid crystal is sealed between oppositely disposed glass substrates, and a voltage is applied to the liquid crystal to drive it. On one of the two oppositely disposed glass substrates, a plurality of pixels is formed in a matrix. In each pixel, a transparent display electrode of ITO (Indium Tin Oxide) or the like is formed, and a switching element such as TFT is connected to each display electrode.

The gate electrode and the drain electrode of the TFT of each pixel are respectively connected, for instance, to a gate line formed in the row direction and to a data line formed in the column direction, which are formed in the area between pixels. If the gate line is selected when gray-scale data is outputted on the data line, the gate of the TFT is turned on to enable the gray-scale data to be written from the drain region connected to the data line to the display electrode connected to the source region.

Referring to Figures 8 and 9, the wiring structure of a liquid crystal display is described in more detail. Figure 8 shows part of the plane of a liquid crystal display 1 manufactured by the conventional module making process. Inside the periphery of an array substrate 2, a colour filter substrate 4 is formed, and further inside the periphery of the colour filter substrate 4, a sealing agent 6 is formed. The area surrounded by the sealing agent 6 is an image display area, where many data line 10/gate lines 46 are intersecting at right angles to form many pixels in a matrix.

The OLB electrodes formed in the area surrounding the array substrate 2 are compression bonded by ACF (Anisotropic Conductive Film) to the leads on one side of a plurality of TCPs 12 on which a driver IC 30 is mounted. One TCP 12 corresponds, for instance, to every 200 of wirings 10 formed on the array substrate 2, but the wirings 10 are simplified in the figure. To the other side of the TCPs 12, a printed wiring board 32 is soldered.

The plane shape of the data lines or gate lines is shown in Figure 9. The OLB electrodes 40 compression bonded by ACF to the leads on one side of the TCPs 12 have a width of, for instance, 50 to 150  $\mu\text{m}$  and a length of, for instance, 3 mm, and connected to the signal or gate lines 10 in one end thereof. The width of the data

lines/gate lines 10 is 10 to 50  $\mu\text{m}$ , and the length thereof is 20 cm for instance. The widths and lengths of the OLB electrode portions 40 and the data lines/gate lines 10 depend on the size and wiring density of the display.

Figure 8 is in a simplified form for clarity, but, for a colour display in a VGA display mode, the data lines/gate lines shown in Figure 9 are arranged in a number of  $640 \times 3 = 1920$  in the row direction and 480 in the column direction to form a matrix.

A large number of data lines and gate lines are arranged in a matrix to form a liquid crystal display panel, as described above, and in addition, elements such as TFTs are formed. Thus, there is a problem of defects caused by static electricity in the manufacturing process of the liquid crystal display panel.

The static failure constituting a problem in the manufacturing process of the liquid crystal display panel and the conventional prevention measures therefor are briefly described below. The gate wirings and data wirings of a TFT array are electrically insulated by an insulation layer. For instance, a glass substrate as the array substrate is fixed by vacuum suction onto the plate of the apparatus for manufacturing the liquid crystal display, but the so-called peeling charge or the like occurs when the glass substrate is removed from the plate by deactivating the vacuum suction at the end of the process. Accordingly, static buildup is easily caused in the manufacturing process of the display panel of TFT/LCD by various reasons. The static buildup in gate lines or data lines causes a voltage considerably larger than the actual driving voltage to be applied to TFTs or wiring intersections, producing breakdown of the insulation film or the like. As a result, the function as switching elements is disabled or a fatal defect such as a line defect is caused.

The anti-static failure measures for preventing such static failure include, for instance, the formation of a protection circuit (short ring) as disclosed in the Published Unexamined Patent Application No. 63-220289. This is implemented by providing a reference potential wiring, and providing independent electrical connection between each signal wiring by the use of a two-terminal operation switching element.

Referring to Figure 10, the antistatic failure measures using the short ring in the manufacturing process of a liquid crystal display are described. First, the manufacturing process of a liquid crystal display is described in order of major process steps. The manufacturing process of a liquid crystal display comprises three steps, that is, an array step in which gate lines and data lines are formed on a glass substrate, and switching elements such as TFTs and display electrodes are formed; a cell step in which the formed array substrate and a colour filter substrate are laminated together, and a liquid crystal is injected and sealed by a sealing agent; and a module making step in which the attaching of TAB and the soldering of a printed wiring board are finally carried out.

The short ring is formed simultaneously with the for-

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mation of the data lines in the stage in which the source/drain electrodes of TFTs and the signal wiring are formed, only after the gate lines (gate lines), TFTs, and display electrodes are formed on the glass substrate in the array step. At this stage, all the gate lines and all the data lines are short-circuited using the material for forming the data lines, or connection is made between the reference potential wiring and the gate lines/data lines through the switching elements as described above, thereby to prevent static failure.

Thus, it can be said that the short ring is an effective countermeasure against static failure in the cell step before subsequent cutoff of the short ring, but the short ring cannot be formed before the data lines are formed in the array step, and accordingly, there is no effective countermeasure for preventing static failure almost throughout the array step at present.

However, as the recent liquid crystal display has a larger size and high definition, the length of the main line of gate lines and the number of gate lines increase, and the thickness of the interlayer insulation film becomes thinner. As a result, static buildup occurs in the gate lines formed on the glass substrate before the short ring has not been formed yet, breaking the interlayer insulation film in a pixel.

Accordingly, it is needed to take measures against static electricity in all the stages of the manufacturing process of a liquid crystal display.

It is an object of the present invention to provide a liquid crystal display in which the occurrence of static failure before the formation of the short ring is prevented, and a method for manufacturing the same.

It is a further object of the present invention to provide a liquid crystal display in which the occurrence of static failure is prevented in substantially all the stages of the manufacturing process thereof, and a method for manufacturing the same.

#### Disclosure of the invention

The invention provides an active matrix liquid crystal display in which switching elements are formed in the pixel area on a substrate, comprising: a set of first metal wirings formed on the substrate and being disconnected in a partial area thereof; an insulation layer formed on the first metal wirings so as to fill in the partial area, and having through holes formed on the first metal wirings on both sides of the partial area; and a second metal wiring formed on the insulation layer as to fill in the through holes, and electrically connected to the first metal wirings.

Further, the invention also provides a method for manufacturing an active matrix liquid crystal display in which switching elements are formed in the pixel area, comprising: forming a set of first metal wirings being disconnected in a partial area thereof on a substrate on which the switching elements are to be formed; forming an insulation layer filling in the partial area on the first

metal wirings; forming through holes in the insulation layer on the first metal wirings on both sides of the partial area, respectively; and forming a second metal wiring electrically connected to the first metal wirings on the insulation layer so as to fill in the through holes.

Thus, in accordance with the present invention, lower-layer wirings to be formed at the initial stage in the manufacturing process of a liquid crystal display, for instance, gate wires, are disconnected in a predetermined area when they are formed, thereby to cause the static electricity building up in the gate lines to be discharged in this area. Accordingly, the pixel failure due to static electricity in the step prior to the formation of the short ring can be prevented.

Moreover, in the step of forming the short ring, the disconnected gate lines can be restored to the original gate lines by connecting them to the other metal wiring layer, and the antistatic measures can be transferred to the short ring.

In addition, the partial area of the first metal wirings is preferably formed at such a position that the areas of respective ones of a set of first metal wirings are substantially equal, and if the partial area is not formed within the pixel area of a liquid crystal display, it can be formed outside the pixel area.

#### Brief Description of the Drawings

The invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 showing the wiring structure of the liquid crystal display according to the embodiment of the present invention;

Figure 2 is a plan view of the wiring structure of the liquid crystal display according to the embodiment of the present invention;

Figure 3 is a cross-sectional view of the wiring structure of the liquid crystal display according to the embodiment of the present invention;

Figure 4 showing the method for manufacturing a liquid crystal display according to the embodiment of the present invention;

Figure 5 showing the method for manufacturing a liquid crystal display according to the embodiment of the present invention;

Figure 6 showing the method for manufacturing a liquid crystal display according to the embodiment of the present invention;

Figure 7 showing the method for manufacturing a liquid crystal display according to the embodiment

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of the present invention;

Figure 8 showing the wiring structure of a prior art liquid crystal display;

Figure 9 showing the wiring structure of a prior art liquid crystal display; and

Figure 10 is a figure for explaining the antistatic failure measures using a short ring in a prior art manufacturing process of a liquid crystal display.

#### Detailed Description of the Invention

The preferred embodiment of the present invention is described using Figures 1 to 7.

The wiring structure of the gate lines of the liquid crystal display according to the preferred embodiment of the present invention is described using Figures 1 to 3. In this embodiment, the description is made on the assumption that the liquid crystal display is a colour liquid crystal display of a VGA display mode, which has a display area having a size of about 10 inches.

Figure 1 is a partially enlarged plan view of the peripheral portion of the panel of the liquid crystal display according to the present invention.

Data lines 10 and gate lines 46 formed on the array substrate 2 of the liquid crystal display are extending from the display area to OLB electrode portions 40 through a sealing agent 6 sealing a liquid crystal. A matrix-shaped area surrounded by the gate lines 46 and the data lines 10 is a pixel area, and display electrodes 24 are formed on the array substrate in the pixel area. In each display electrode 24, at the intersection of the gate line 46 and the data line 10, a TFT 26 for instance is formed as a switching element. Onto the array substrate 2, a colour filter substrate (not shown) is laminated through the sealing agent 6. Onto the OLB electrode portions 40 on the array substrate, a TCP (not shown) is bonded, for instance, by ACF.

An enlarged plan view of the area surrounded by a circle 44 in Figure 1 as seen from the array substrate side is shown in Figure 2, and the cross-sectional view thereof is shown in Figure 3. Using Figures 2 and 3, the characteristic features of the liquid crystal display according to the present invention are described.

On a glass substrate 2, the gate lines 46 made of a metal film of, for instance, Mo, Ta, Cr, Al or the like, and having a thickness of about 0.3  $\mu\text{m}$  are formed. For a display area of 10 inches, the width of the gate lines 46 is about 20  $\mu\text{m}$ , and the pitch is about 330  $\mu\text{m}$ . The length of the gate lines 46 is about 20 cm.

The gate lines 46 are disconnected, and on the edges of the disconnected lines, discharge projections 52 and 54 are formed on both sides of a discharge gap 50 so as to provide a spacing of, for instance, about 6  $\mu\text{m}$ , between them. The discharge gap 50 is formed at a position between the OLB electrode portion 40 and the pixel area, for instance, at a position which is about 0.5 mm apart from the pixel area toward the OLB electrode portion. The discharge projections 52 and 54 are positioned substantially at the centre of the edges of the disconnected portion of the gate line 46. Both the height of the discharge projections 52 and 54 from the gate line edges and the width thereof are about 6  $\mu\text{m}$ .

On the gate lines 46 and between the discharge gap 50, a gate insulation film 56 of, for instance, a silicon oxide film is formed to a thickness of the order of 0.4  $\mu\text{m}$  for instance. Two through holes 58 are made in the gate insulation film 56 in the vicinity of the discharge projections 52 and 54 of the respective gate lines 46.

Filling in the through holes 58, a metal wiring layer 48 of, for instance, Al having a thickness of about 0.3  $\mu\text{m}$  is formed on the gate insulation film 56.

As described above, the liquid crystal display according to the embodiment of the present invention has a construction in which the gate lines are disconnected in part thereof, and the disconnected gate lines are electrically connected by the upper metal wiring layer via the through holes formed in the insulation film on the gate lines.

Now, the method for forming the gate lines of the liquid crystal display according to the embodiment of the present invention is described using Figure 4 to 7.

A metal film 42 of such as Mo, Ta, Cr, or Al is deposited, for instance, by sputtering on the whole surface of a glass substrate 2 to a thickness of about 0.3  $\mu\text{m}$  for instance (Figure 4). Then the metal film 42 is patterned to form the gate electrodes (not shown) and gate lines 46 of a TFT (Figure 5). For a 10-inch display area, the width of the gate lines 46 is about 20  $\mu\text{m}$  and the pitch is about 330  $\mu\text{m}$ . The length of the gate lines 46 is about 20 cm.

At this point, each gate line 46 is patterned so as to be disconnected in part thereof, and a discharge gap 50 and discharge projections 52 and 54 are formed as shown in the plan view of Figure 3. The spacing of the discharge gap 50 is in the order of 6  $\mu\text{m}$ . The discharge projections 52 and 54 are positioned substantially at the centre of the edges of the disconnected portion of the gate lines 46. The height of the discharge projections 52 and 54 from the edges and the width thereof are both about 6  $\mu\text{m}$ . Although the shape of the discharge projections 52 and 54 is rectangular in this embodiment, it is not limited to this, but it may be triangular or circular.

It is desirable that the spacing of the discharge gap 50 becomes smaller, but, in view of the positioning precision of the exposure apparatus in the manufacturing process, sufficient discharge is obtained even if it is in the order of 4 to 10  $\mu\text{m}$ . Preferably, the discharge projections 52 and 54 are positioned at the centre of the gate line edges if possible. This is to prevent discharge to the different adjacent gate line from occurring if the discharge projections are biasedly provided, because the wiring spacing (pitch) of the gate wirings becomes narrower as the display density of the liquid crystal display increases.

play becomes higher.

To determine the position of the discharge gap 50, various points should be considered in view of the likelihood of discharge, but, in a pragmatic approach, it is only necessary to determine the position of the discharge gap so that the areas of the disconnected gate lines 46 are substantially equal. However, since the possibility of such position giving equal areas being in the pixel area is high, it is desirable to provide a discharge gap 50 in the area between the pixel area and the OLB electrode 40 (for instance, the lead area). In this embodiment, the discharge gap 50 is formed between the OLB electrode portion 40 and the pixel area, at a position spaced apart by about 0.5 mm from the pixel area.

Thus, in accordance with the present invention, the wirings for the gate wirings can be formed in the array step and simultaneously a discharge gap as a counter-measure against static failure can be formed, so that static failure in the process prior to the formation of the short ring can be prevented.

Then a gate insulation film 56 is deposited, for instance, by a CVD process, on the whole surface to a thickness of about 0.4  $\mu\text{m}$  for instance. At this point, the discharge gap 50 is filled in with the material for forming the gate insulation film 56 (for instance, a silicon oxide film) (Figure 6).

Thereafter, although not shown, after steps for forming a TFT, such as of depositing a silicon nitride film and amorphous silicon, the gate insulation film 56 is patterned to make two through holes 58 in the gate insulation film 56 in the vicinity of the discharge projections 52 and 54 of each gate line 46. Then, over the whole surface, a metal wiring layer, about 0.3  $\mu\text{m}$  thick, for forming data lines is formed. The through holes 58 are filled in with the deposited metal wiring layer. As the wiring material, a metal material equivalent to the gate wiring material including Al can be used.

Then, the metal wiring layer for forming data lines is patterned to form data lines. At this point, a patterning is simultaneously performed to form a gate line connecting layer 48, which electrically connects the disconnected gate lines 46 through the through holes 58 on both sides of the discharge gap 50 for the gate lines 46 (Figure 7). The OLB electrodes 40 to be connected to the gate line edges are also formed of the data line wiring metal at the same time. The formed OLB electrodes 40 are about 50  $\mu\text{m}$  wide and about 3 mm long.

At this stage, the disconnected gate lines are electrically connected to each other and lose the function as means for preventing static failure, but, at the same time, by forming the conventional short ring when the data lines are formed, antistatic failure measures can be taken from then on.

As described above, in accordance with the present invention, the gate lines are disconnected with a predetermined length and width, so that the discharge of the charged gate lines occurs in the disconnected part. After the insulation film is grown, the static electricity building

up in the gate lines is discharged in the disconnected part to break the insulation film in the disconnected part, but no effect on pixels is caused so that the occurrence of pixel failure can be prevented. By connecting the gate lines on both sides of the gap with the metal wiring constituting the other layer, the original gate line is restored and the effect of the antistatic measures is lost. However, at this point, a circuit for removing static electricity (short ring) can be simultaneously formed, and the function of antistatic measures is transferred to this short ring.

Accordingly, throughout the array and cell steps of the manufacturing process of a liquid crystal display, preventive measures against static failure can be provided. With the method for manufacturing a liquid crystal display of the present invention, it is not needed to increase the manufacturing process steps, but, only the modification of the mask used for patterning is needed to provide antistatic failure measures in the conventional manufacturing process.

The present invention can be variously modified without being limited to the above embodiment.

For example, although, in the above embodiment, the gate line connecting layer 48 was formed simultaneously with the formation of the data lines using the metal material for forming the data lines, other metal material can of course be used if an increase in the manufacturing process steps is not a matter of concern.

Further, since the present invention is characterized in that the lower metal layer (namely, the metal layer formed at the early stage of the manufacturing process) is provided as antistatic failure means to prevent static failure from the early stage of the process, it is to be understood that the present invention can apply not only to a liquid crystal display of the so-called bottom gate type (or inverse-stagger type) TFT structure as described in the above embodiment, in which gate lines are formed prior to the formation of data lines, that is, the gate lines are positioned below the data lines, but also to a liquid crystal display of the so-called top gate type (or stagger type) TFT structure.

#### Claims

1. An active matrix liquid crystal display in which switching elements (26) are formed in the pixel area on a substrate (2), said liquid crystal display comprising:

a set of first metal wirings (46) formed on said substrate having a partial area electrically disconnected thereof;

an insulation layer (56) formed on said first metal wirings so as to fill in said partial area, and having through holes (58) formed on said first metal wirings on both sides of said partial area;

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and

a second metal wiring (48) formed on said insulation layer so as to fill in said through holes said second metal wiring electrically connected to said first metal wirings.

2. A method for manufacturing an active matrix liquid crystal display in which switching elements (26) are formed in a pixel area, said method comprising:

forming a set of first metal wirings (46) having a partial area electrically disconnected thereof on a substrate (2) on which said switching elements are to be formed;

forming an insulation (56) layer filling in said partial area on said first metal wirings;

forming through holes (58) in said insulation layer on said first metal wirings at both sides of said partial area, respectively; and

forming a second metal wiring (48) electrically connected to said first metal wirings on said insulation layer by filling in said through holes.

3. A method for manufacturing a liquid crystal display as claimed in Claim 2 wherein said partial area of said first metal wirings (46) is formed at such a position that the areas of said respective first metal wirings of said set are substantially equal.
4. A method for manufacturing a liquid crystal display as claimed in Claim 2 wherein said partial area of said first metal wirings (46) is formed outside said pixel area.
5. A method for manufacturing a liquid crystal display as claimed in any of Claims 2 to 4 wherein the edges of said set of first metal wirings (46) which are opposed to each other in said partial area are shaped into a projection (52, 54) so as to facilitate the discharge due the buildup of static electricity.
6. A method for manufacturing a liquid crystal display as claimed in any of Claims 2 to 5 wherein said first metal wiring layer (46) is connected to the gate electrode of said switching elements (26).
7. A method for manufacturing a liquid crystal display as claimed in Claim 6 wherein said second metal wiring layer (48) is formed using the material for forming the signal input side electrode of said switching elements (26) and simultaneously with the formation of said signal input side electrode.
8. A method for manufacturing a liquid crystal display

as claimed in any of Claims 2 to 5 wherein said first metal wiring layer (46) is connected to the signal input side electrode of said switching elements (26).

9. A method for manufacturing a liquid crystal display as claimed in Claim 8 wherein said second metal wiring layer (48) is formed using the material for forming the gate electrode of said switching (26) elements and simultaneously with the formation of said gate electrode.

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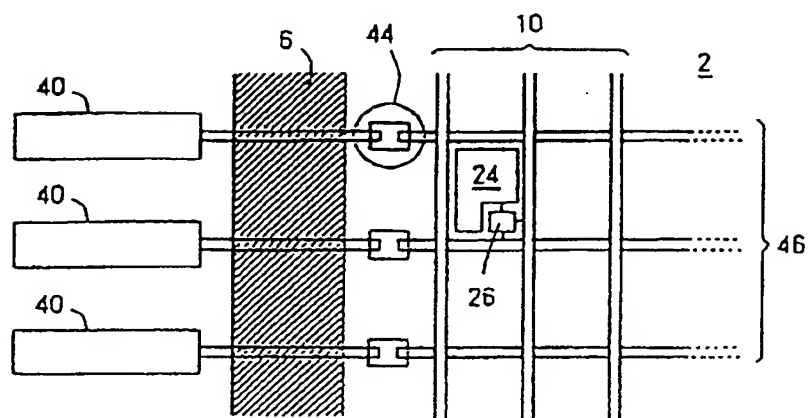


FIG. 1

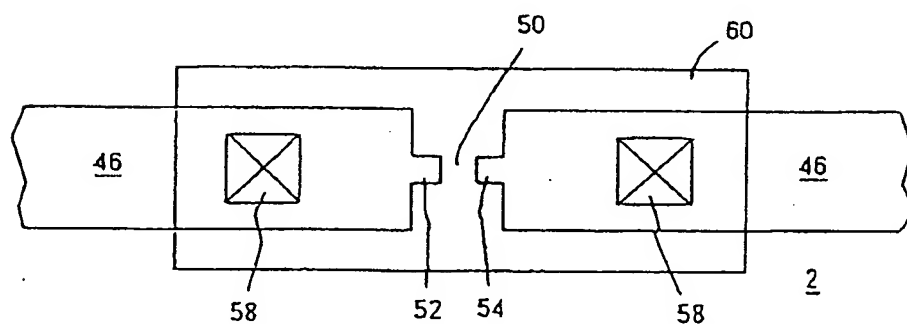


FIG. 2

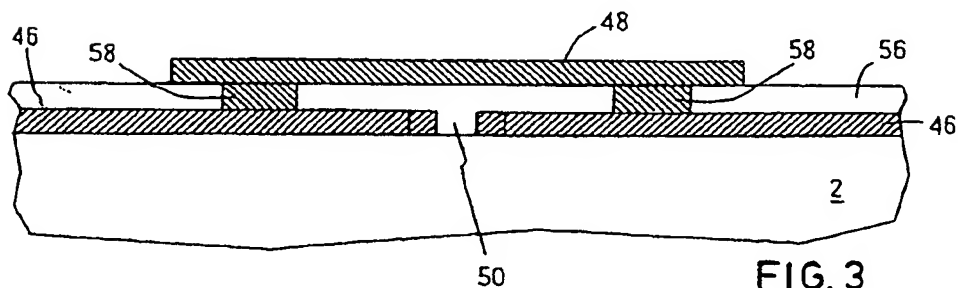


FIG. 3



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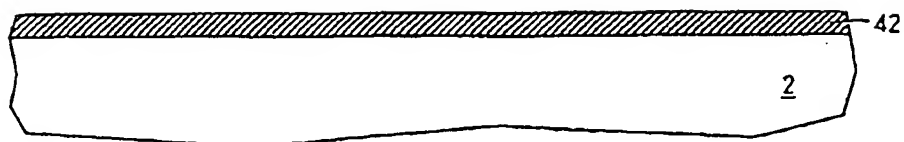


FIG. 4

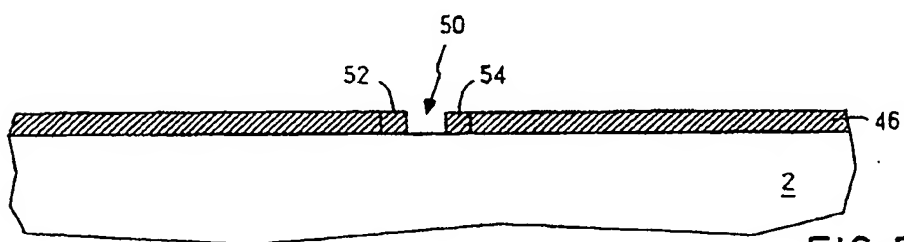


FIG. 5

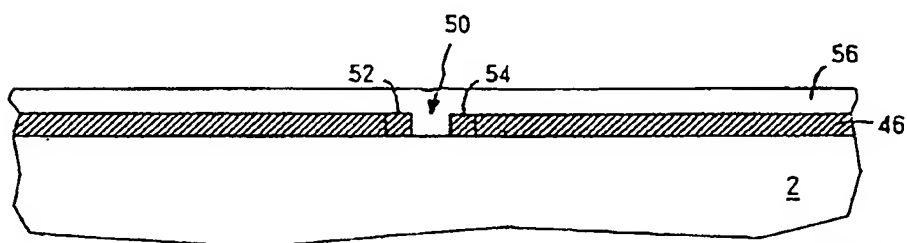


FIG. 6

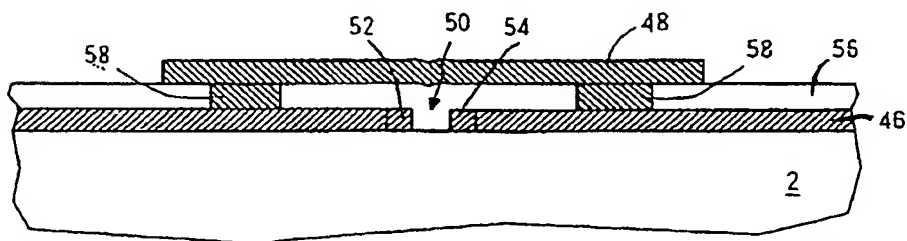


FIG. 7

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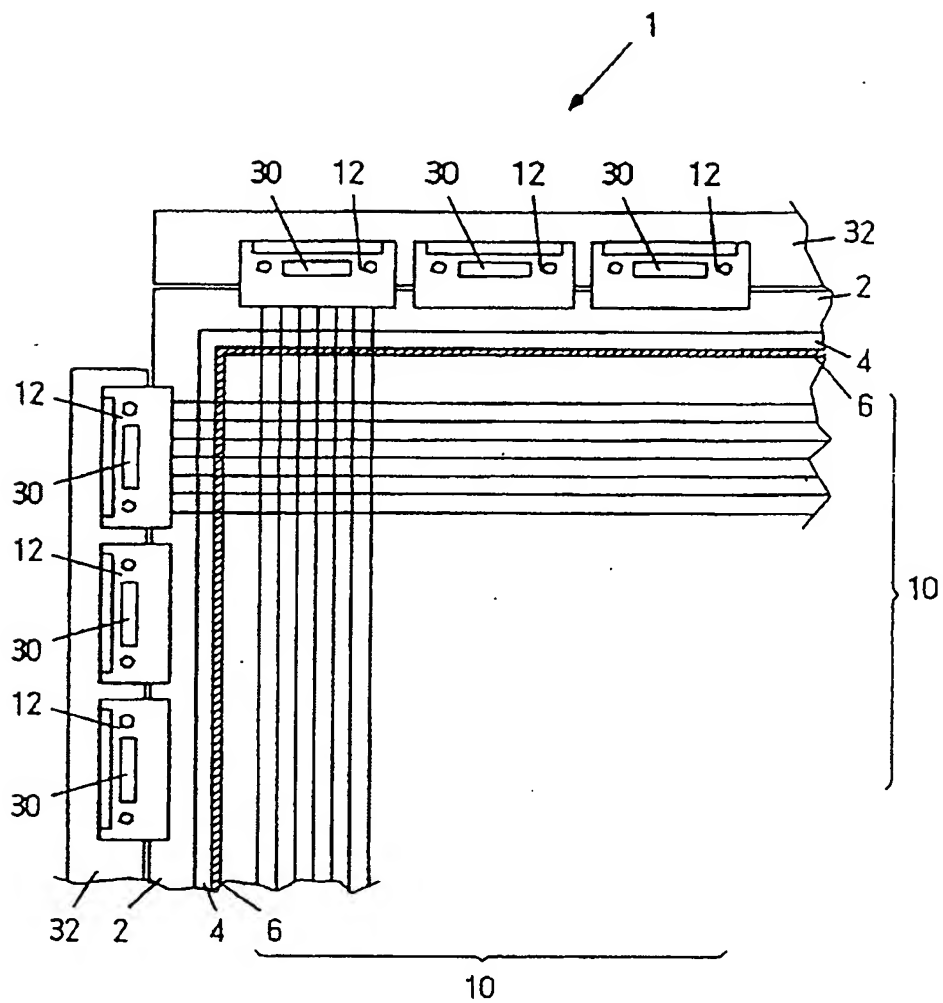


FIG. 8

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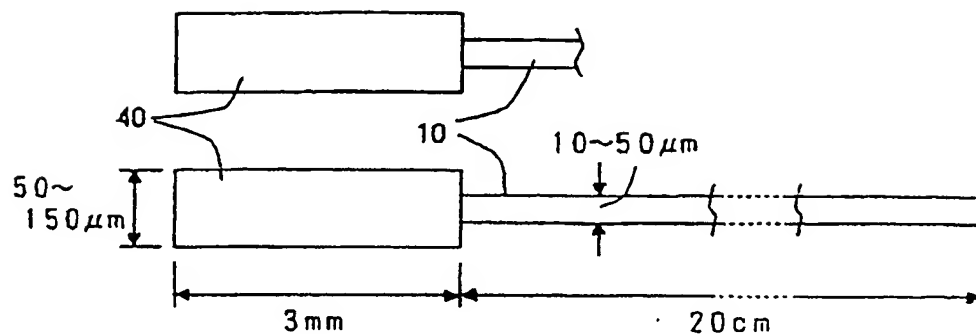


FIG. 9

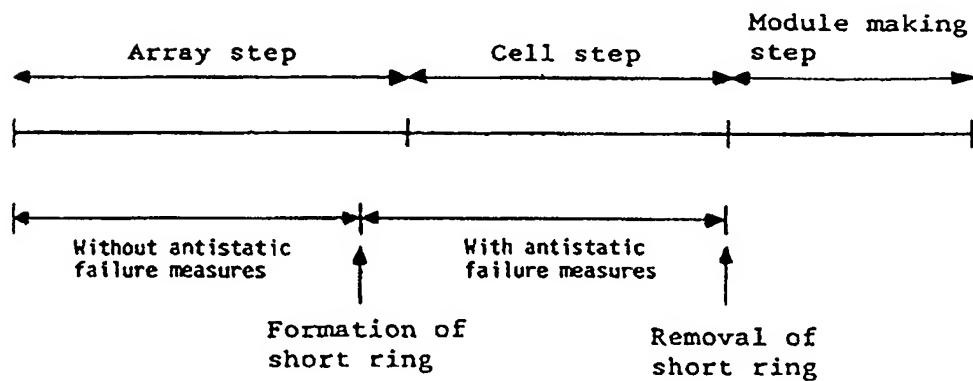


FIG. 10

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## EUROPEAN SEARCH REPORT

Application Number  
EP 96 30 7538

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP 0 504 792 A (TOKYO SHIBAURA ELECTRIC CO) 23 September 1992 * column 5, last paragraph - column 8, paragraph 1; figures 6,7 *	1-3,5,6	G02F1/136
A	SID INTERNATIONAL SYMPOSIUM DIGEST OF TECHNICAL PAPERS, SAN JOSE, JUNE 14 - 16, 1994, vol. 25, 14 June 1994, MORREALE J, pages 255-258, XP000462708 LIBSCH F R ET AL: "ELECTROSTATIC DISCHARGE DAMAGE: HOW MUCH PROTECTION IS NEEDED FOR AMLCDS" * page 258, right-hand column, paragraph 1 *	1,2,4-6	
A	PATENT ABSTRACTS OF JAPAN vol. 95, no. 007 & JP 07 181509 A (SHARP CORP), 21 July 1995, * abstract; figure 2 *	1-6	
A	US 4 894 690 A (OKABE KAZUYA ET AL) 16 January 1990 * column 4, last paragraph - column 5, paragraph 1; figure 2 *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.6) G02F
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 6 February 1997	Examiner Wongel, H
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons * : member of the same patent family, corresponding document	

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